THE BRITISH JOURNAL

OF

OPHTHALMOLOGY

FEBRUARY, 1940

COMMUNICATIONS

AN IMPROVISED EYE-IRRIGATOR FOR USE IN THE FIELD

BY

H. B. STALLARD

R.A.M.C.

IN the 1914-1918 European War it happened on some occasions that as many as 2,000 men with their eyes damaged by the vapour of poisonous gas, particularly mustard, arrived at a dressing station or a casualty clearing station and found there inadequate provision for immediate treatment or no facilities at all, a situation both pitiful for the afflicted men and humiliatingly uncomfortable for the medical officers who were compelled to stand by with empty hands.

In the present campaign if poison gas should be used it is hoped that the eye-shade, a celluloid device worn constantly by all troops in the theatre of military operations, will afford them ocular protection against droplets of mustard or lewisite sprayed from aeroplanes on to them when on the line of march or in the trenches. The service respirator protects the eyes against gas vapour. However, in spite of these guards it is probable that some men will suffer ocular injury from the mustard or lewisite droplets entering the eyeshade which has been perforated by flying particles or a bullet from an aeroplane opening machine gun fire simultaneously with the liberation of the gas, or due to the shade becoming accidentally displaced whilst the soldier falls to the ground or takes cover.

The enemy may employ " spray " over rest camps and sites behind the lines for the purpose of harassing large bodies of troops who may have become careless about cover and anti-gas protection. These men would thus be rendered unfit to act as reinforcements.

Injuries of the eyes from vapour may also occur when respirators are discarded or not put on in a recently contaminated zone in which the odour of gas is so faint as to avoid detection by anyone but an especially trained soldier.

Although the eye casualties from this source may be considerably fewer at any one time than in the last war it is as well to make reasonable preparation for such.

It is undesirable from a military point of view to encumber the equipment of " forward " medical units, such as the regimental aid post and the advanced and main dressing stations of the field ambulance, any further than is absolutely essential for the immediate needs of the wounded. The carrying of stores of lotion, undines and receivers in sufficient bulk to treat heavy eye casualties from gas would impose a burden that would often be quite unnecessary. For the purpose of economy in cost and size of the equipment and for its advantage in rapid working the following suggestion is put forward.

Apparatus.—An irrigator is improvised by taking an empty 2 gallon petrol tin, boring 4 holes in its bottom, each sufficient in size to admit the base of a discharged bullet case, the cap of which has been perforated. The bases of these 4 bullet cases are soldered into the tin making water-tight junctions. The whole tin is cleaned and sterilized. To the projecting extremities of the bullet cases 4½ feet of rubber tubing is attached (see Fig. 1) and into the free ends of these are inserted metal irrigator nozzles each with a lever switch control to cause or stop the flow of lotion. The tin is suspended from a 6 foot wooden stake driven into the ground and each of the 4 irrigator tubes is operated by an orderly.

A suitable quantity of sodium bicarbonate or sodium chloride salt is carried by the unit and with boiled water it is made up into either a 2 per cent. solution of the former or a 0·9 per cent. of the latter. The tin is filled with the lotion. Eusol, 1 in 10 cold, has been recommended for the treatment of mustard gas injuries and the Americans at the end of the 1914-1918 war claimed that dichloramine T 0·5 per cent. in chlorcosane reduced the degree of corneal erosion and necrosis from mustard gas droplets and prevented secondary infection.

It is generally thought that after a droplet of mustard oil has entered the eye treatment is of little avail in conserving useful sight.

In the case of injury from gas vapour the ocular symptoms do not come on for 6 to 8 hours after exposure and whilst many recover in 3 to 12 weeks some of the severe cases may develop corneal complications which impair sight and lead to recurrences

FIELD CONTAINER FOR EYE LOTION

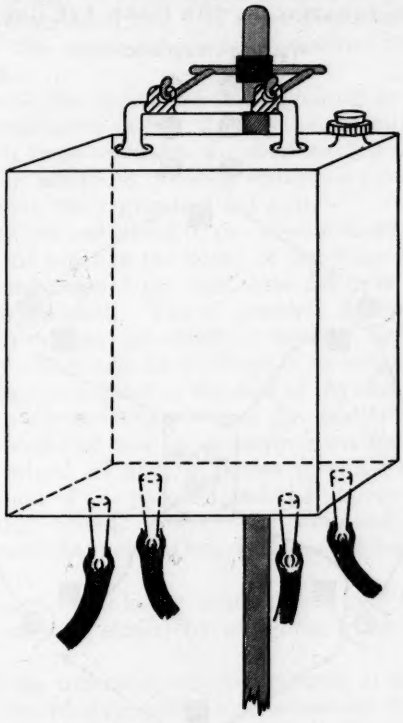


FIG. 1.

Two gallon petrol tin—improvised container in the field for eye-lotion, anti-gas. Four perforated discharged bullet casings soldered into base of tin and connected by rubber tubing to irrigator nozzles. Tin mounted on a standard inserted into the ground.

of ulceration and keratitis as long as 10 years after the injury was sustained.

I feel that the psychological effect of prompt relief of pain by the instillation of gutt. pantocain 1 per cent. (cocaine is contra-indicated in these cases) of ol. parolein for the possible solvent effect of this on any residual mustard in the conjunctival sac,

the copious irrigation of the eye and the supply of a tinted eye-shade may assist the rapidity and efficiency with which the soldier is evacuated from the regimental aid post through the field ambulance and casualty clearing station to entrain for the base hospital.

SCHEME FOR TREATING IN THE FIELD EYE GAS CASUALTIES

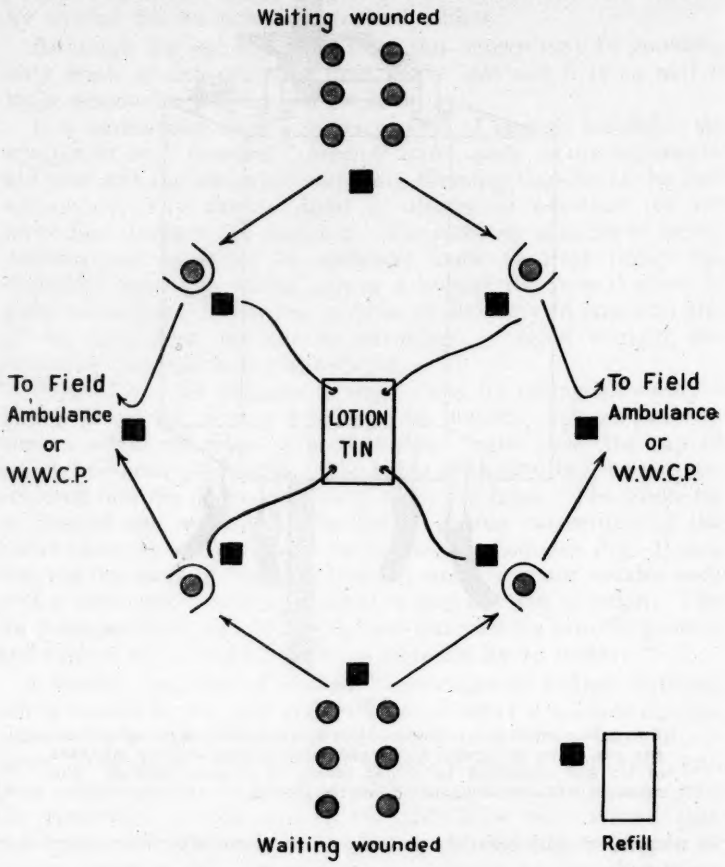


FIG. 2.

1 and 2. Instil pantocain 1 per cent. and 40 seconds later ol. parolein. 3, 4, 5 and 6. Irrigate with sod. bicarb. 2 per cent. (or sod. hypochloride or dichloramine T. 0·5 per cent. solution in chlorcosane). 7 and 8. Instil ol. parolein and supply new eye-shades. 9. Attends to refills of lotion tins.

Such therapeutic attentions would also have a good effect on the morale of the troops who have witnessed the casualties but have been unaffected themselves.

Distribution.—One irrigator would probably suffice the needs of a regimental aid post, two an advanced dressing station and 4 to 6 might be necessary at a casualty clearing station. (There is no occasion to halt wounded again at the main dressing station on the line of evacuation but it is more desirable to carry them through from the advanced dressing station to the casualty clearing station.)

Organization.—The duties of a team working on an irrigator is shown diagrammatically in Fig. 2. This organization is designed for dealing with large numbers of casualties and so would apply to the work of an advanced dressing station or a casualty clearing station rather than the regimental aid post.

The casualties are assembled in two double files (*e.g.*, one file to the north and the other to the south of the irrigator). Orderlies 1 and 2 instil pantocain 1 per cent. into the eyes followed in 40 seconds with ol. parolein. The ol. parolein is allowed to remain in the conjunctival sac for about 3 minutes before irrigation. Orderlies 3, 4, 5 and 6 each have charge of an irrigating nozzle. A little bleach cream is applied to the skin of the cheeks, the oil-skin anti-gas cape is drawn closely round the soldier's neck and the eyes irrigated whilst he sits on an improvised seat. The bleach cream is then wiped off and he passes to either orderly 7 or 8 for the instillation of ol. parolein and the supply of a new eye-shade, preferably tinted. Thence the wounded are evacuated through the usual channels. Orderly 9 replenishes the supply of lotion in the tins.

In the advanced areas badly injured men may be led in files, connected by ropes or sticks, by a sighted guide from the field ambulance.

After 1 hour the treatment may be repeated at any appropriate site along the line of evacuation, *e.g.*, advanced dressing station, casualty clearing station and ambulance train.

Allowing 3 minutes for the treatment of both eyes (1½ minutes each eye) 1 team of orderlies with 1 irrigator could treat 80 men in 1 hour, 2 teams 160, 3 teams 240 in 1 hour and so on.

In heavily contaminated cases the personnel carrying out the treatment will have to work in anti-gas clothing and respirators and the wounded pass through a decontamination and cleansing centre.

THE ORIGIN OF ABNORMAL RETINAL CORRESPONDENCE

BY

T. A'B. TRAVERS

MELBOURNE

THIS essay is the final report of a British Medical Association research scholarship. The early portion of the investigation was described in a previous paper (1).

The ideas set out here follow naturally upon the first report, and it is essential that the latter be understood for the ideas to be readily comprehended. For this reason, I will briefly recapitulate the findings which are particularly relevant to the present thesis.

In concomitant squint there are two main types of suppression occurring in the deviated eye:

1. Suppression of the false image of the object of regard. This image, if not suppressed, would cause diplopia. The suppression is easy because the image upon the fixing macula is so much clearer than that upon the peripheral retina of the deviated eye.

This type of suppression does not vary with retinal correspondence. The typical suppression scotoma may be demonstrated by a method which I described as the " Colour Test " (1).

2. Suppression of the area of retina in the squinting eye which has the same " local sign "† as the fixing macula. This suppression prevents a " confusion."*

Suppression of this variety is intimately associated with retinal correspondence. The typical suppression scotomata may be easily demonstrated by a method I have called " The mirror-screen test " (1).

If correspondence is normal, there is only very slight macular suppression in the deviated eye—unless there is amblyopia also.

If retinal correspondence is abnormal, there is a much larger and deeper area of suppression in an eccentric part of the retina of the deviated eye.

Now, abnormal retinal correspondence is an abnormality of binocular vision and is a binocular phenomenon.

So, although I have referred above to suppression scotomata

† The " Local Sign "[3] of a sensory impression is the inherent quality that conveys to the brain the place of origin of the impulse. Thus, if we are touched on the hand, the local sign of the sensory impression is referred by the brain to the part of the hand touched. Retinal local signs inform us of the direction of objects. The local sign of the macula is the " straight ahead " direction.

* A " Confusion " is the name given by Von Kries[2] to the phenomenon of an image from the squinting eye which appears in consciousness as if it were *superimposed* upon the fixation object. This is different from a *diplopia* image which is seen *to one side* of the fixation object.

that occur " in the deviated eye," one should think of each eye and monocular field as an integral portion of the *binocular field*. It is *convenient* to refer to a suppression scotoma that occurs in one eye—but one should not forget that this suppressed area is really in a part of the binocular field.

Suppression can only exist in one eye if the other eye is fixing. One part of the binocular field can only be suppressed so long as *fixation* is present.

Much of the difficulty of understanding abnormal correspondence arises in this manner. The field of each separate eye in a squinter is normal. It is only when the eyes are examined binocularly that an abnormality is present. For—just as a squint depends upon the relative positions of the two eyes (for one eye cannot squint by itself) so the visual abnormalities of squint depend upon the functioning together of both eyes.

In the normal person, then, the two monocular fields overlap with little or no *macular* suppression. This is because the two visual lines intersect upon the object of fixation, and this allows the two maculae to be presented with similar images. A fluctuating and alternating slight macular suppression is simply a manifestation of normal retinal rivalry. If the macula of one eye habitually holds the ascendency in binocular vision, then that eye may be called the " master-eye."

Even in the normal person, there is suppression of the physiological diplopia images in the *peripheral* field.

In squint the visual lines are not both directed upon the fixation object, and thus suppression arises in the binocular field.

The diplopia image is suppressed irrespective of the type of retinal correspondence.

A confusion is prevented by suppression of that part of the binocular field which has the same local sign as the fixing macula. The position of this area will vary according to the correspondence.

Thus, if correspondence is normal, the part of the field that is suppressed will be in a line with the macula of the deviated eye. If correspondence is abnormal, the portion suppressed will be in line with an eccentric part of the retina.

I have shown that the suppression scotomata associated with abnormal correspondence alter as the retinal correspondence changes. This is typically seen after a corrective operation. The size of the scotoma is roughly proportional to the angle of anomaly. As the latter diminishes, so does the area of suppression. When retinal correspondence becomes normal again, suppression ceases.

Now can one argue, in the reverse way, that macular suppression is the first stage in the development of abnormal correspondence?

This problem is associated with the interpretation of direction. The relative position of objects is determined by their relation to the visual line. Thus one says that a thing is to the " right " or " left " of some *fixation object*. The visual line is taken as the central line around which all directions are orientated.

The power of visually discriminating direction then, must depend largely upon a single spot of high visual acuity (which

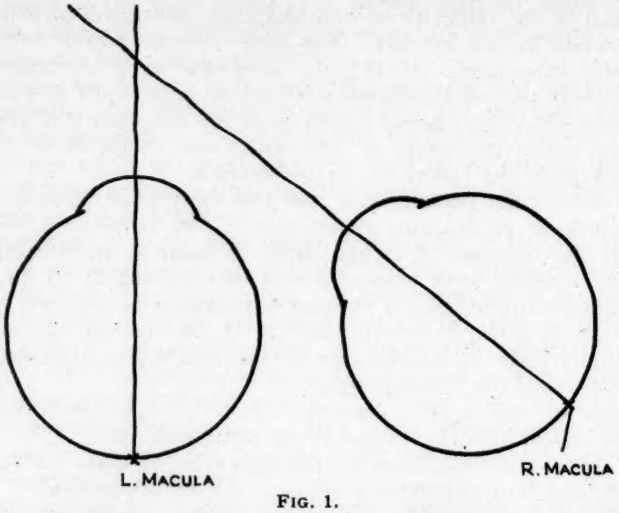


FIG. 1.

forms the central spot of fixation) surrounded by a large area of low visual acuity.

Impressions which arise in the " low acuity areas " of the retina are then easily orientated in relation to the central visual line.

In the squinter there is an alteration in the binocular field because there are two visual lines pointing in different directions—as in Fig. 1. Let us suppose that Fig. 1 represents the eyes of a child who has only recently commenced to squint. His retinal correspondence will be normal.

If suppression of some part of the binocular field did not occur, then there would ensue a confusion. The object imaged upon the macula of the deviated eye would " rise up into consciousness " as if it were superimposed upon the fixation object. This is prevented by a macular suppression in the deviated eye—or more accurately, by a suppression of a part of the binocular field in line with the deviated macula.

As this occurs, the visual acuity curve of the deviated eye is greatly altered as in Fig. 2.

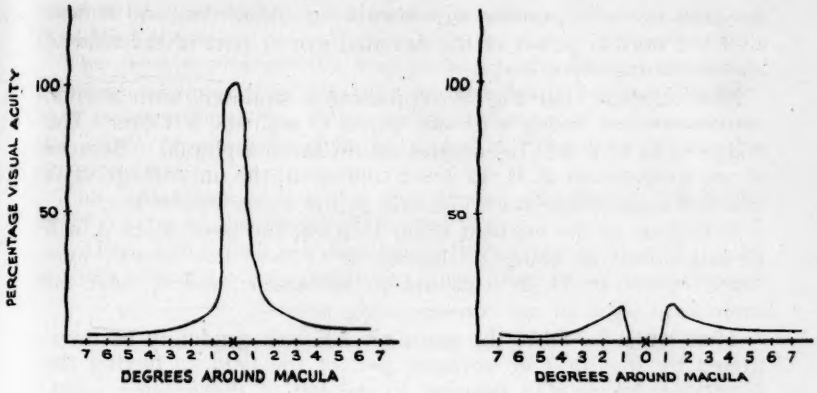

PERCENTAGE VISUAL ACUITY
100
50
7 6 5 4 3 2 1 0 1 2 3 4 5 6 7
DEGREES AROUND MACULA
100
50
7 6 5 4 3 2 1 0 1 2 3 4 5 6 7
DEGREES AROUND MACULA
(A) NORMAL
(B) DURING FIXATION OF OTHER EYE

FIG. 2

It follows, then, that while one eye is fixing, the power of the other for discriminating direction will be greatly altered.

There will still be only one visual line in the binocular field—that of the fixing eye. Directions of objects will be orientated around this central point. The macular suppression in the

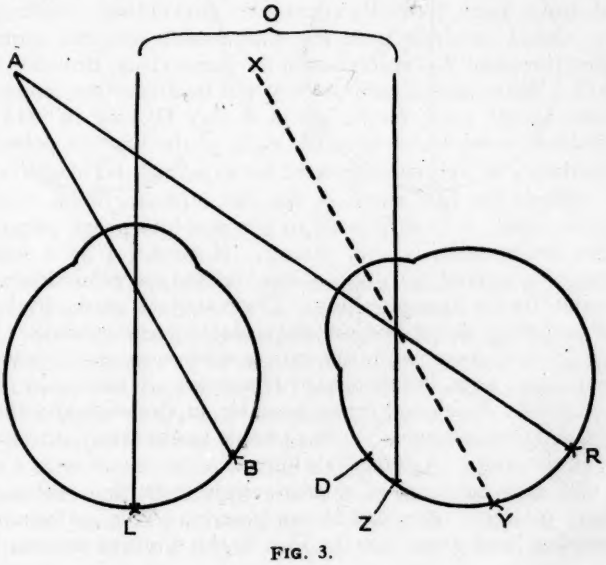


FIG. 3.

deviated eye will prevent any disturbing influences, and it will alter the normal power of the deviated eye or part of the field of discriminating direction.

Now suppose that Fig. 3 represents a squinter, with normal correspondence, fixing a distant object O with the left eye. The image of O at Z will be suppressed (to avoid diplopia). Because of the suppression of R (to avoid confusion) the only image of A to reach consciousness will be that in the fixing eye at B.

Therefore, at the moment when L. fixes, the position of A will be interpreted as being to the left of O—and not as if it were superimposed on O (as it should be, because L. and R. have the same local signs or are corresponding points).

Thus when L. fixes, the meridian AR will gradually be interpreted by the right or deviated part of the field as having the directional value of a position to the left of the fixation point. Then another meridian—say XY—will assume by juxta position to AR the same directional value as the visual line of the fixing eye. This is an abnormal correspondence.

Then Y will have the same local sign as the fixing macula L, and Y will be suppressed in turn—to prevent a confusion. (The area of suppression around Y will be much larger than that around R, because the visual acuity of Y is much lower than that of R.)

This shows how the angle of anomaly increases. The point Y would move away from R, constantly preventing confusion.

This would continue until the suppression scotoma around Y included the point Z—which lies in the same visual direction as the point O. When this occurs there would be no further tendency to increase, as any point to the left of Z (say D) has, in *both eyes*, a directional value which is to the right of the fixation point.

This theory is well substantiated by experimental evidence.

As regards the first stage in the development of an abnormal correspondence, it is very hard to get absolute proof because the subjects are necessarily very young. However, I have seen two children who undoubtedly had normal retinal correspondence when first tested by the synoptophore. Their squints gradually became worse and they developed an abnormal correspondence. I was unable to test them with the mirror-screen as their powers of concentration were insufficient. However, in each case it was clear that they developed first a macular suppression and then the abnormal correspondence. I was unable to show any intermediate stage as the angle of anomaly altered.

It will also be seen in mirror-screen tests that an angle of anomaly of much over 15° is uncommon. This is because the suppression is so great that (in Fig. 3) the scotoma around Y has

reached Z, and there is no further tendency for confusion, as described above.

The reverse process—the way in which the abnormal correspondence changes after operation and gradually becomes normal, may be seen clinically. The gradual lessening of suppression as the angle of anomaly changes is easily demonstrated on the mirror-screen.

The explanation of how this happens is given below. (It is the exact reverse of the process described earlier.)

In Fig. 4 the right eye was formerly convergent, but the eyes are now straight after operation. There used to be an abnormal

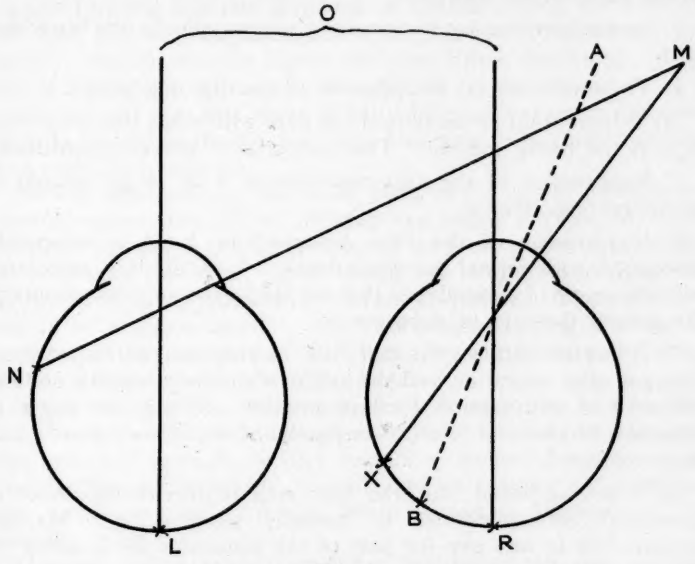


FIG. 4.

correspondence in which the left macula, while fixing, had the same local sign as the point X in the right retina.

Now, while L. fixes, the image of M at N, in the fixing eye, will be the only image of M seen in the binocular field, because its image at X will be suppressed. Therefore, M will be seen as if it were to the right of O, and not superimposed on O. Therefore some meridian AB, in the right part of the field will then assume the same directional value as the fixing visual line. Again the correspondence of the fixing visual line and the line AB will change—the point B gradually approaching R. As this occurs, the suppression around B will become less and less as the retinal

visual acuity rises. When B reaches R, and correspondence becomes normal, suppression will cease—or may be of the alternating macular type which is the manifestation of normal retinal rivalry.

Summary

1. In the normal binocular field there are two visual lines which meet upon the fixation object. This arrangement permits binocular fixation with little or no suppression.

2. In squint there are two visual lines which do not meet upon the fixation object. This would cause diplopia and confusion unless suppression occurred.

3. In squint there are two areas of suppression in the binocular field.

4. There occurs: (*a*) Suppression of the diplopia image.

(*b*) Suppression of the part of the field which has the same local sign as the fixing macula. This suppression prevents confusion.

5. Suppression of the area described in 4 (*a*) is not related to retinal correspondence.

6. Suppression of the area described in 4 (*b*) is intimately associated with retinal correspondence. It is directly associated with the angle of anomaly, in that the larger the angle of anomaly, the greater the area of suppression.

7. It has been shown clinically that as abnormal correspondence changes after operation and the angle of anomaly lessens, so does the area of suppression become smaller. When the angle of anomaly becomes O, and correspondence is normal, there is no suppression.

8. It is suggested that the first step in the development of abnormal correspondence is macular suppression. Macular suppression in one eye (or part of the binocular field) alters the power of discriminating direction in the deviated component of the binocular field. This allows the abnormal perception of direction to develop.

BIBLIOGRAPHY

1. TRAVERS, T. a'B.—*Brit. Jl. of Ophthal.*, Vol. XXII, p. 577, 1938.
2. VON KRIES, J.—*Arch. f. Ophthal.*, Vol. XXIV, p. 117, 1878.
3. LOTZE.—Referred to in Schafer's Text-Book of Physiology, Vol. II, p. 1137. Young J. Pentland, 1900.

BUPHTHALMOS WITH FACIAL NAEVUS AND ALLIED CONDITIONS

BY

A. J. BALLANTYNE

GLASGOW

THE following notes form a postscript to an article with the above title published in this Journal some years ago.[1] The paper dealt primarily with the case of a boy seen at the age of three weeks with a facial naevus affecting the skin and mucous membranes supplied by the first two divisions of the 5th cranial nerve on the left side, and with buphthalmos of the left eye. The cornea was steamy, and the tension high; but after Elliot trephining, at the age of five weeks, the tension fell and the cornea cleared.

The patient was lost sight of until he was two years and nine months old, when the trephine scar was seen to be ectatic and the lens completely opaque.

He was next seen on March 26, 1938, at the age of 8 years, the general appearance of the affected eye being unchanged. The slit-lamp showed a patchy atrophy of both the pigment layer and the stroma of the iris. Vision in this eye amounted to light perception with a very doubtful field of projection. The right eye was in all respects normal. He had been attending a clinic on account of " nervousness " and was reported to have twitching of the right eye and angle of the mouth.

It was thought that extraction of the opaque lens was feasible and this was attempted through an inferior section; but vitreous was lost, and later in the day expulsive haemorrhage occurred. The eye was subsequently excised, and on histological examination was found to contain a fairly extensive angioma of the choroid. (Fig.)

The history of facial twitching (confirmed on one or two occasions) suggested that there might be an intracranial angioma, but radiograms of the skull gave no indication of such a lesion.

The finding of a choroidal angioma in the buphthalmic eye recalls the cases of facial naevus with *secondary* glaucoma reported by Milles (1884), Lawford (1885), Snell (1886), Steffens (1902), de Haas (1928), Wagenmann (1900) and Paton and Collins (1919). So far as the writer is aware, none of the published cases of naevus with *buphthalmos* gave evidence of the presence of a choroidal angioma; but in some, for example those of Sturge (1879), Horrocks (1883), Schirmer (1860), Yamanaga (1927) and Aynsley (1929),[2] a greater or less degree of fulness and tortuosity of the

1. BALLANTYNE, A. J., *Brit. Jl. of Ophthal.*, Vol. XIV, p. 481 (1931).
2. These references are given in detail in the original paper.

Angioma of the choroid in Dr. A. J. Ballantyne's case of facial naevus with buphthalmos.

retinal veins was described, and this may have been associated with a vascular lesion in the choroid.

The fact that facial capillary naevus may co-exist with buphthalmos, with simple glaucoma, or with secondary glaucoma, and that in at least one case of buphthalmos (the one under discussion) and in several cases of secondary glaucoma, a choroidal angioma has been found, lends support to the view that, in the eye, the primary fault is a vascular lesion in the choroid. The facial naevus is congenital and we may take it that the choroidal lesion is also congenital. It is not necessary to suppose that this takes the form of a recognisable angiomatosis in every case. It may be, in some cases, sufficiently developed to establish the glaucomatous process during ante-natal life (buphthalmos), while in others, the evolution of the neoplasm is delayed until adult life, and we get simple or secondary glaucoma. This, broadly speaking, is the theory advanced by Ginsburg and by Hudelo.

It goes without saying that the absence of evidence of choroidal angioma in many of the published cases does not exclude the possibility that such a lesion was in fact present.

I am indebted to Dr. I. C. Michaelson for the microscopic demonstration of the choroidal angioma in this case.

A STUDY OF THE EFFECTS OF LIQUID MUSTARD GAS UPON THE EYES OF RABBITS AND OF CERTAIN METHODS OF TREATMENT

BY

WING COMMANDER P. C. LIVINGSTON, O.B.E., F.R.C.S.E.

and

FLIGHT LIEUTENANT H. M. WALKER, M.D.

THIS work was undertaken with a view to following, step by step, the damage caused to the eyes of mature rabbits by single drops of liquid mustard, and to attempt to evaluate certain methods of treatment. Therefore, when a typical clinical picture of the effect of mustard was obtained and fresh in our minds, attention was directed to the examination and estimation of various methods of preventing or mitigating the graver changes in the eyes.

As is well known, liquid mustard gas acts upon living tissues as a profound chemical irritant; but it appears that even after the immediate potency has subsided, the evil that is wrought lives on in the shape of highly toxic by-products of disintegration. Whereas damage caused by other powerful chemical substances tends to be localised, mustard exercises not only the primary effect but, in a delayed state, it appears to throw forward from cell to cell a destructive activity that knows no calculable bounds. The observations that we have been able to make have convinced us that there is some degree of natural resistance to this violent chemical—at least in the case of rabbits. In a period of seven days we have witnessed eyes totally destroyed, and others, similarly treated, revealing considerably less manifestations of injury.

Twenty-three mature rabbits were used and their average weight was $2\frac{3}{4}$ kgms.; of these fourteen were female. Regarding colour, thirteen were brindle, five white, two black, two gray and one gray-white. The question of colour in relation to resistance is probably not so important as was at first believed, but of all the rabbits, that which was found most gravely affected, was a white rabbit with almost albino eyes.

Technique

Exposure of the eyes to liquid mustard was effected by applying the smallest possible drop (the maximum size was 0·75 c.mm.) from a fine glass pipette to a point selected between 11 and 1 o'clock on the corneal surface, about 2 mms. below the limbus. The eyes were retained open for one minute, and the third lid was controlled by forceps, so that the drop could exercise a

standard effect without admixture with an unknown quantity of tears. The reaction of the tears of a rabbit are alkaline with a pH 8·0. The same sample of mustard was used throughout the whole series.

Solutions and Substances Used

In the first instance it was decided to examine the effect of irrigating the eyes with various solutions, and of instilling certain substances.

The solutions for irrigation subjected to test were, bleach powder B.P. 1:400, pH 10·0, sodium bicarbonate 2 per cent., pH 8·0, saline 1·4 per cent., pH 6·8; Bonnefon's solution (a saturated solution of sodium sulphate 800 grams and sugar syrup 200 grams), pH 7·0. Substances used for instillation were cod liver oil B.P.; liquid paraffin B.P.; benzoyl peroxide; Oil No. 1 (liquid paraffin with added vitamin A 12,000 units and vitamin D 2,000 units per ml.); Oil No. 2 (arachis oil); Oil No. 3 (cod liver oil with added vitamin A 12,000 units and vitamin D 2,000 units per ml.).

A 1:10,000 solution of merthiolate (Eli Lilly) either alone, or with the addition of diffusing factor, was used for its antiseptic effect upon secondary infections. Examination of exudates from swollen and inflamed membrane, however, showed that there was little bacterial infection. The diffusing factor, a substance present in certain tissue extracts, has been shown to have the power of reducing the intercellular barrier, and it was used to ascertain if deeper penetration of the irrigation could be obtained.

It is important here to discuss briefly one or two facts relating to bleach solution B.P. and hydrogen peroxide. In view of the knowledge that in the earliest stages of contamination bleach exercises a retarding influence upon the skin lesions caused by mustard, some experiments were conducted prior to the present study, with various strengths of bleach solution. These experiments consisted of filling the conjunctival sacs of undamaged eyes of rabbits with solutions of bleach in strengths varying from 1:1,000 to 1:50. It was only when the strength reached 1:250 that transient blepharitis and conjunctivitis occurred on the following day. Observations were then made of the effect of these solutions upon corneae scarified with a needle. No material differences were noted between the first and second groups. This encouraged the view that bleach solution 1:400 might, with value, be included for test in the present study. When, however, the technique was changed from a simple pool filling of the conjunctival sac for fifteen minutes, to the projection of the solution upon the cornea through a pipette with the containing flask placed a

foot above the eye, the picture altered. The cornea became clouded and dry, presenting an appearance much like ground glass. The period of lavage was kept at five minutes, and the changes became noticeable in two minutes. These changes occurred in eyes exposed to liquid mustard, and in eyes used as controls. Partly on this account, and because the most serious case was that of a bleach treated rabbit (No. 1) the procedure lost favour.

Experiments similar to those previous experiments with bleach were carried out with hydrogen peroxide, strengths 0·6 per cent., 0·9 per cent. and 1·5 per cent. The merits of this substance were examined since oxidising agents should convert mustard into the non-toxic sulphoxide. Here again the effect upon the corneae was very marked and there was intense oedema of the conjunctivae. Whether this adverse effect is peculiar to rabbits is not known. An instance has been recorded in which the anterior chamber of a patient suffering from hypopyon was irrigated with hydrogen peroxide and the eye saved. Hydrogen peroxide was not used in the present experiments, but a substitute, benzoyl peroxide in oily solution, was tried on the grounds that its liberation of oxygen is less rapid. However, as will be seen, the results from its use were not so good as those obtained from other procedures.

In the irrigation of the eyes during these experiments the greatest care was exercised to ensure that the lotions reached all spaces in the conjunctival folds and the areas in front of and beneath the third lid. The initial irrigations (that is, those given shortly following the application of mustard) were carried out for a period of five minutes, while later irrigations (those given during treatment) were carried out for half a minute. In the instillation of the oil substances, eight drops were given at each application. The merthiolate solutions were run into the eyes through a glass pipette—about 4 c.c. at a time, the lids and conjunctivae having been previously well cleaned with water.

When we had made the preliminary observations and had become familiar with the reactions of the eye to mustard, there were several points that seemed to be significant and to suggest that there might be yet another method of approach to the subject of treatment.

The differentiation made later (see page 77) between a first stage of focal involvement and a second of spread, must be taken into account in the consideration of treatment. During the stage of spread a deep keratitic change occurs throughout the substance of the cornea; once this stage has started it is obviously impossible noticeably to affect its progress by surface applications.

The observation that rabbits showed some varying degree of natural resistance, sometimes fairly strong, to the effect of mustard, seemed to indicate that if we were to mitigate or prevent the stage of spread, we must attempt to increase the natural resistance; and that the only profitable method of approach was through the blood stream. Only in this manner could the deeper tissues affected in the changes be reached. The progressive lesions of the cornea are unlikely to be due to long persistence of mustard as such in the tissues. It has been suggested that mustard, by combination with the free amino groups of the protein molecule, can form a stable toxic substance.

If then, the corneal lesion of mustard is brought about by a fundamental alteration in the biochemical structure of corneal tissue through a chemical action or interaction, the barrier against this can only be the administration through the blood stream of some substance that might inhibit the interaction.

In view of the degree of natural resistance shown by some animals, it was considered desirable first to investigate the possibility of inhibiting or preventing the stage of spread by the administration of a substance, ascorbic acid, that is normally present in the lens and cornea in high concentration. Ascorbic acid* is a substance belonging to a group known as " redox potentials," which maintains a fine balance between the processes of reduction and oxidation by acting, either as a reducing or oxidising agent, whichever action is called for. From a chemical point of view, therefore, it seemed that ascorbic acid might be capable of preventing the interaction between mustard and the corneal tissue which leads to the spreading keratitic change in the cornea. From the medical viewpoint ascorbic acid is non-toxic and can be given in very large amounts, the only limitation being that of cost. Four rabbits were given doses of 500 mgms. intravenously, and the result of the experiment was of such outstanding interest that it opens up a considerable field for further investigation of the treatment of this type of injury.

Clinical Examinations

With the exception of four mornings, daily observations with the loupe and lens were carried on for twenty-eight days. Detailed

* Ascorbic acid (vitamin C) is prepared synthetically, occurs in minute colourless crystals and is readily soluble in water. It is stable in the solid form when kept in sealed glass bottles. A 10 per cent. solution can be prepared for intravenous injection and can be sterilised by filtration; it must not be boiled. The solution remains stable only when kept in the dark, under nitrogen, or with the addition of an antoxidant, such as sodium sulphite in a strength of 0·2 per cent. There is no known toxicity of ascorbic acid, and very large doses can be given if required. Ampoules of ascorbic acid in various strengths can be obtained. Saturation can be ensured by an intravenous dosage of 1,000 mg. 1st day, 500 mg. 2nd day, 200 mg. 3rd day and 100 mg. 4th and 5th days.

shorthand notes were taken on each occasion. In this way it was possible to record the state of closure of the lids, sensitivity to light, quantity and quality of discharges, progress of lid scarring, keratitic changes and involvement of the iris. In addition, direct smears and cultures were made, photographs taken, and sections cut for recording histopathological changes.

Clinical Features of Mustard Drop Contamination

With the lids open and well controlled and the third lid restricted by forceps, a drop of the liquid mustard was placed upon the cornea about 2 mms. from the limbus and at a position corresponding to between 11 and 1 o'clock. The eyes were kept open for one minute. Observation through the loupe of the behaviour of the drop showed that for five to ten seconds there is no noticeable activity. It remained as an oily globule bounded by a sharp rim of demarcation. A small break in the tissue surface then allows the drop to throw out a projection which, in turn, is arrested while another starts out from a fresh angle. This movement, pause and new movement, continues until the globule has assumed a somewhat starlike shape. During this process, it seems that the drop is having its effect in a downward direction also, because after a lapse of five minutes, the cornea is found to stain with fluorescein deeply over the area invaded.

The local damage, which consists of destruction of the cells of the corneal epithelium down to and apparently including Bowman's membrane, is almost immediate; and it is felt that no form of counter attack can retard the damage at this stage. The chemical interaction between liquid mustard and the tissues of the eye is remarkably strong and rapid. In order to examine this interaction a drop of the liquid was placed at the usual area on the right cornea of a control rabbit (No. 18) and the eye allowed to close and remain untreated for fifteen minutes. Thereafter, the conjunctival folds, lid angles and corneal surface, were stroked with a platinum loop, and the secretions collected and transferred to the left eye. No inflammatory or other changes were seen in this eye and the inspections were stopped after 96 hours. The right eye, however, revealed keratitic and lid changes.

The ocular damage in rabbits is of a type that follows a fairly regular course. This description applies not only to cases left without any kind of treatment, but also to those of a fairly large group which, a few minutes after the application of mustard, received a lavage for five minutes. First there appears the area of staining already noted, with its sharp edges and deep green coloured base. After a lapse of ten to fifteen minutes there is a

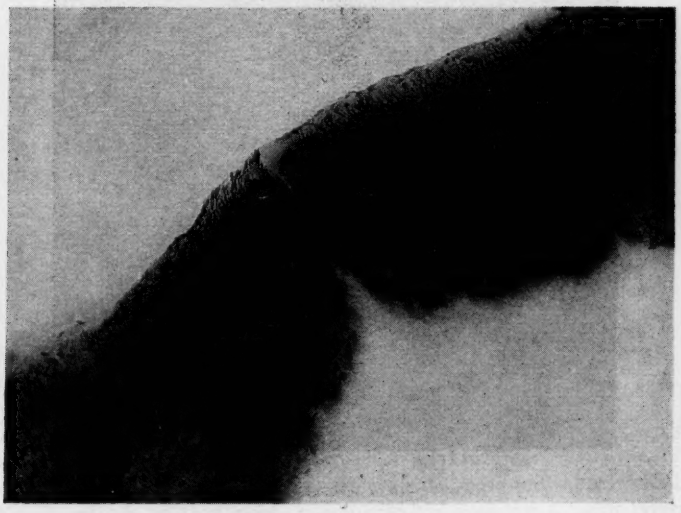
tendency to close the eye in presence of strong light. There now appears a fine corneal haze which surrounds the central point of injury. The superficial epithelium shows fine linear striae, which later combine by transverse bars until a cobweb effect results. After 24 hours there is usually a great change in the picture. The primary area continues to stain, although often its extent is not much increased. There is now dense corneal oedema, the fine cobweb effect being masked by changes further below the surface, and the area of damage now staining may equal four to five times the primary seat of injury. A mucoid discharge, becoming whitish and thick later, makes its appearance and there is often blistering of the conjunctival folds. In about one-third of the cases the iris will have contracted. After 48 hours the corneal damage in the form of deep keratitis may prevent a thorough examination of the size of the pupil or the iris pattern. After four days the discharges are usually sufficiently intense to cause

RABBIT No. 1 (Observation Group).

Left eye photographed on the 12th day, after 4 days treatment with merthiolate 1:10,000 showing very acute involvement with massive leucoma and staphyloma (*a*) and oedema of the conjunctiva (*b*).

Note.—The white areas in these illustrations are caused by the reflection of the photographic lamp.

firm adherence of the lids. There are thick crusts on the outside and much muco-pus within. The cornea, however, although greatly involved by keratitic changes, does not stain readily. Where staining occurs, it is very fine and of a branching character. At this stage the iris has in most cases resumed its normal shape and size, and from examination of the iris pattern in cases in which constriction was a characteristic feature, it seems that this process is due more to the stimulus of irritation than to exudative or other changes. It is now that the lid damage becomes apparent, and ectropion appears in the worst cases, together with serious contraction and often a membranous condition such as is seen in diphtheritic conjunctivitis. The lid scarring tends to be linear, and extends from the lid margins backwards and into the deeper conjunctival folds, so that the margins seem as if notched in three or four places. In contra-distinction to this picture, there may be instances in which there is an attempt at spontaneous recovery aided possibly by the simple use of water-washings. Where the damage is intense, the process may advance to a general disintegration of the whole corneal substance with development of large leucomata or staphylomata, as observed in rabbit No. 1.



RIGHT EYE OF RABBIT No. 12

Showing extensive corneal damage. There is desquamation of surface epithelium and endothelium on Descemet's membrane. A perforation is present, which is partially filled with exudate. For general report see page 87.

The foregoing represents a digest from a large volume of case notes taken while watching the progress, uncontrolled except as previously noted, of the tissue reactions to the influence of a drop of liquid mustard.

The experiments themselves were divided into three groups, according to the course of treatment adopted namely, the observation group of nine rabbits; the treatment group of nine rabbits; and the ascorbic acid treatment group of five rabbits.

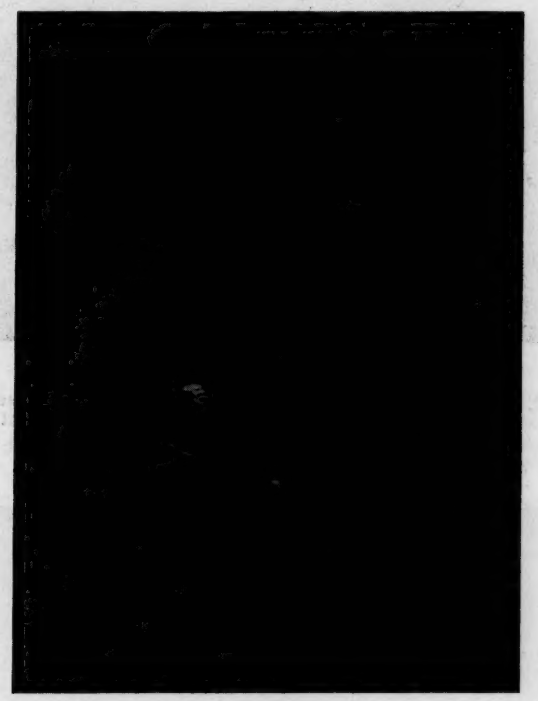
The Observation Group

The principal object here was to examine the effect of a drop of mustard oil in eyes receiving one lavage five or fifteen minutes after exposure, and in other eyes not receiving lavage. Table No. I indicates the technique adopted and gives a brief summary of the end results. The group was kept under observation for

RABBIT No. 2 (Observation Group).

Right eye photographed on the 25th day, 8 days after the cessation of treatment with merthiolate 1:10,000, and cod liver oil, showing a horse-shoe shaped staining area (*a*) within which keratitic changes of a non-staining type have taken place. Upper and lower lids appear almost normal. The loss of hair (*b*) due to early discharges is a characteristic feature.

seven days, after which time an attempt was made to cure the more serious features by using merthiolate 1 : 10,000 (with or without diffusing factor) and cod liver oil. Considering the inflammatory states to be dealt with, the results of this treatment



RABBIT No. 3 (Observation Group).

Right eye photographed on 11th day, after 5 days treatment with merthiolate 1:10,000 showing corneal changes, loss of regular light reflex on the surface (*a*). Typical lid scarring with its V-shaped contraction is shown above (*b*), while scarring of the third lid (*c*) and mucoid discharges are present.

were extremely satisfactory. The addition of diffusing factor to the merthiolate appeared to have an advantage.

Particulars of one experiment might be noted here. Rabbit No. 4 which offered such a remarkable resistance as a control, was exposed a *second* time, being treated with cod liver oil (8 drops) in the right eye and liquid paraffin (8 drops) in the left eye five minutes *before* the application of mustard. This experiment was made with a view to discovering whether, in a case of

RABBIT No. 3 (Observation Group).

Left eye photographed on the 11th day, after 5 days treatment with merthiolate 1:10,000, showing the severe muco-purulent discharge that occurs in some cases, characterised for the most part by its extreme whiteness.

RABBIT No. 6 (Observation Group).

Right eye photographed on the 20th day, after 14 days treatment with merthiolate 1:10,000 and cod liver oil. This case demonstrates the marked thickening of the upper lid (*a*) which remained swollen tense and deeply infiltrated, while the lower lid shows a characteristic ectropion.

known resistance, an oily film would give any useful prophylaxis. Whether or not the initial resistance had been lowered by the first experiment, cannot be defined, but the reactions exhibited in the second experiment suggested that the presence of oil tended to spread out the effect of the mustard. After 24 hours there was in the right eye " a diffuse, fine, keratitic haze over most of the cornea," while in the left eye " the oedema was definitely greater than in the right eye, and the cornea was hazy with a condition just as serious as found in cases untreated." Water washes and continuation of cod liver oil treatment cleared the right eye in fifteen days. At that time, the left eye still showed keratitis, scar tissue was extensive, but the lids were free from active signs.

The Treatment Group

The purpose of this group was to estimate the value of various methods of treatment of the eyes after exposure to mustard. The group consisted of nine rabbits, one black, four brindle, three white and one gray-white. Table No. II indicates the line of treatment adopted in each case. Treatment was carried out twice daily, and in order to maintain a proper balance, irrigations subsequent to the initial five-minutes lavage, consisted of simple washing out for about half a minute. Oily drops were used liberally, usually eight being counted.

In examining the features of experimental injury caused by a drop of mustard oil there are three stages to be considered:

(1) *The stage of immediate focal involvement.*—As a point at which to check the havoc caused by mustard, this stage must be dismissed. The direct contact of the corneal epithelium with this substance which possesses such profound toxicity, must certainly kill the adjacent cells, and having killed them, by its permeation must kill further cells and structures in its close vicinity. From a practical standpoint it is impossible to hope to receive a soldier or civilian for treatment within five minutes of contamination. By that time the first damage has been done.

(2) *The stage of spread.*—Treatment here becomes a matter of limiting the wave of secondary keratitis which, by its manner of fine cobweb infiltration, moves forward and downward in an increasing circle of attack. Against this there is, first, the varying degree of natural resistance well shown in the observation group of experiments. How much this applies to humans it is difficult to say, but that it exists in some degree would appear certain when consideration is given to the general experiences of clinical ophthalmology. For example, a phlyctenular conjunctivitis or keratitis may respond quickly in one case, while in another receiving the same treatment, it may drag on for weeks or

even months. Of the many cases of mustard gas eye injury during the Great War a large proportion recovered with apparently no lasting harm, while some remained permanently damaged and yet others, showing a transient period clear from features, developed gas keratitis in anything from ten to sixteen or more years after known exposure. Secondly, there is the principle of using cod liver oil, which is known to assist healing, to fortify the corneal structure, and raise some kind of barrier against the intensely active by-products resulting from neighbouring cell destruction. So far as the eye is concerned, how much this property of cod liver oil is due to the vitamin A content, how much to other contents of the oil, such as the peroxidases, and how much to the mechanical protective coating, cannot be assessed; but it is strongly indicative (as shown in the case of rabbit No. 4) that cod liver oil possesses some quality not held by a mineral oil. Furthermore, in concluding the study of the observation group (from the seventh day onward) it was shown that advanced damage responded well when cod liver oil formed part of the treatment. In several cases keratitis was checked and the corneae began to clear. It was only in such destructive involvement as occurred in rabbit No. 1 that the conditions leading to blindness resisted treatment. The choice of a specific oil remains open, but cod liver oil is easily obtainable, with or without added vitamin A and requires no sterilization.

(3) *The stage of secondary infection.*—From examination of smears taken from discharges of eyes showing particularly severe reactions, it was found that there was a high proportion of cellular debris with comparatively few bacterial cells. Between the fifth and eighth days smears from seven rabbits showed, " a few Gram positive, short, fine bacilli, a few short diplo-bacilli, a few Gram positive cocci." Therefore, the profuse discharges were more in the nature of massive desquamations than of bacterially charged pus. However, it is recognised that mustard infection in the human eye would probably invoke active corneal ulceration and much and varied bacteriological flora. Although the smear count in the rabbits was relatively low, the use of merthiolate, especially with added diffusing factor, helped very definitely to clear up the condition, and when used in conjunction with cod liver oil, helped to advance resolution. It was considered that the optimum period of value for antiseptics was between five and seven days. Their continued use after seven days, showed in one or two cases indications of returning congestion as if the best purpose of the antiseptic had been served.

Concerning the diffusing factor, it must be understood that for practical purposes this substance is still in the experimental stage;

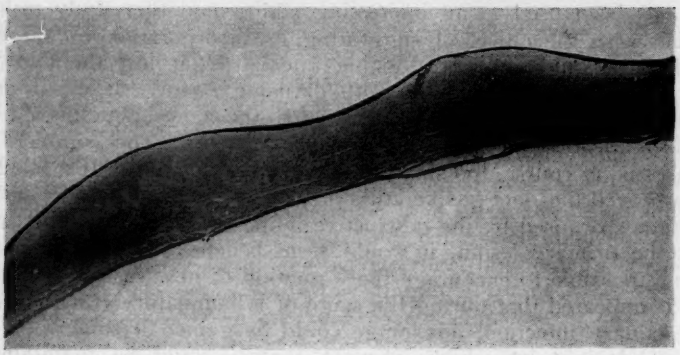
it has been used as an interesting addition in this study rather than with the object of suggesting its incorporation in lotions. There is one point of possible interest regarding the clinical appearance of eyes treated with diffusing factor. It was found that there appeared a tendency for the development of fine vascularisation at the corneo-scleral margin. The number of cases is, of course, too small to lay down any ruling. If it should be proved that late gas keratitis in man is the result of a vascular handicap caused by the destructive influences at work at the time of the primary lesion, it would seem beneficial if such a thing were possible to encourage the formation of new vessels.

It appeared that during the stage of inflammatory reaction and secondary infection, advantage could be gained if some method were devised by which intimate contact could be maintained between lotions and tissue folds. Particularly would this apply to man where frequently, owing to oedema, slippiness of lids and blepharospasm, it is impossible to apply any treatment to more than a very limited area. From this arose the design of a special irrigating speculum later to be described.

Following are extracts from the progress notes of the nine rabbits in the treatment group:—

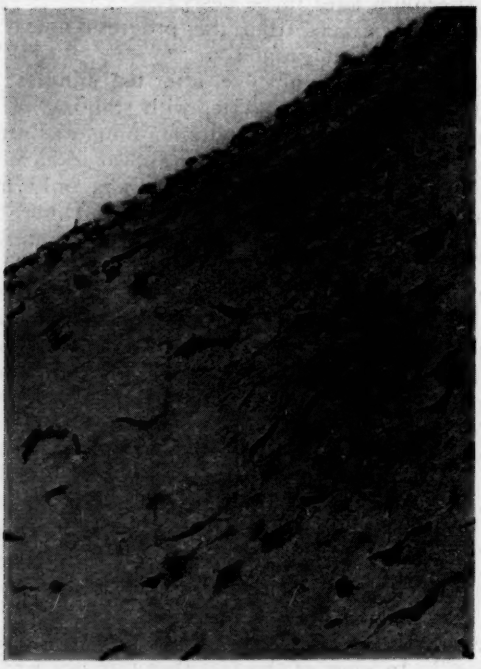
Rabbit No. 10.—The right eye, after ten minutes, showed fine corneal opacities and linear striae, with staining of one-third of the corneal surface. After 24 hours staining was much reduced, and after 48 hours the animal did not appear to have suffered any inconvenience. The corneal structure was only faintly hazy. On the third day treatment was stopped and there was no discharge, no conjunctivitis, and only very fine marking on the third lid.

The left eye stained over the centre of the cornea and a fine V-shaped scratch was noted. It was considered that this must have been due to the eye having been touched with the pipette as the mustard was applied. Lavage with Bonnefon's solution This seemed to cause more discomfort than lavage with other lotions. After 24 hours the eye was one-quarter open and the conjunctiva was severely inflamed. After 48 hours the eye was half open and there was some watery discharge. There was greater sensitivity to light than in the case of the right eye. The cornea showed a localised opacity; the iris was clear. After five days the discharge was very slight and there was no lid scarring; and on the seventh day the cornea was clearing rapidly. On the fourteenth day treatment was stopped as the condition was " very satisfactory with the eye wide open and free from discharge and the cornea almost clear." In view of the fact that this eye was exposed for more than twice the period of exposure of the right eye before the initial lavage, the end result can be considered very promising.



RABBIT No. 11.

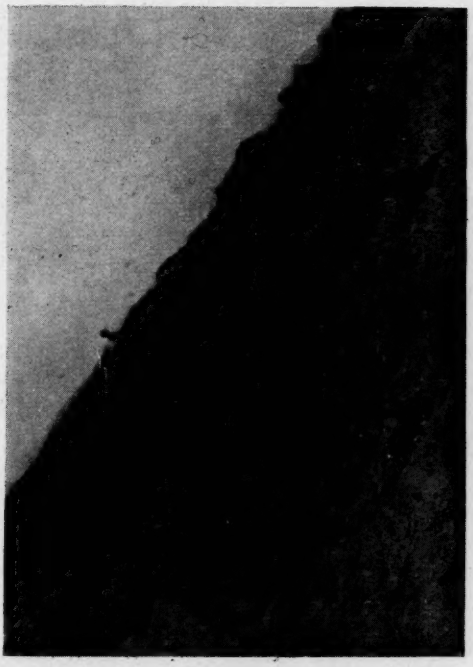
Photomicrograph of the left cornea—×45. Showing marked irregularity due to swelling and oedema of the substantia propria of the cornea.



RABBIT No. 12.

Photomicrograph of the right cornea—×350. Showing fragmentation of the corneal corpuscles, presence of eosinophils, and swelling of endothelium on Descemet's membrane.

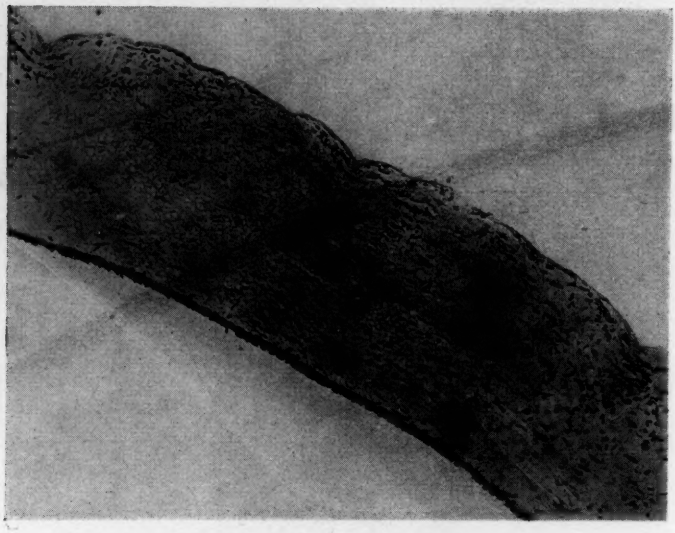
Rabbit No. 11.—The right eye had rather a large deposit of mustard which tended to run inwards. After 24 hours there was severe conjunctivitis, blepharitis and oedema of the cornea. After 48 hours the eye was matted with muco-pus; the cornea was hazy and stained in the centre, and the third lid showed contraction. After four days mucopurulent discharge glued the lids; the cornea was hazy and the iris difficult to see. On the sixth day there was dense opacity of the cornea and marked scarring of the upper lid. Merthiolate with diffusing factor was added to the treatment on the tenth day. The discharge diminished rapidly, and had almost disappeared by the seventeenth day. The cornea, however, was " milky white with a bluish tinge, the whole having the appearance of a fine section of a sea-shell." Vascularisation was present in a fine capillary network. The keratitic changes showed as concentric rings. Ectropion was marked.



RABBIT No. 12.

Photomicrograph of the corneal substance of the right eye—×500. Endothelium on Descemet's membrane, showing swelling and vacuolation, with partial desquamation.

The left eye within 48 hours showed very definite blistering of the upper lid, mucopurulent discharge and deep keratitis. In three days the lids were firmly stuck. There was oedema of lids with contraction; and dense corneal opacity. In view of the marked reactions, the benzoyl peroxide treatment in this case was withdrawn and substituted by merthiolate with diffusing factor and cod liver oil. By the thirteenth day the cornea looked almost clear and light was well tolerated. However, lid contractions and



RABBIT No. 12.

Photomicrograph of the cornea of the right eye—×110. Showing irregularity of cornea, loss of epithelium, cloudy swelling of lamellae, infiltration by eosinophils, fragmentation of corneal corpuscles, and some desquamation of endothelium.

a mucoid discharge persisted. The animal was destroyed on the seventeenth day and the eyes kept for examination.

Rabbit No. 13.—Here it was considered of interest to extend the duration of mustard attack. The drop applied to the right eye was slightly larger than usual. Within 24 hours the cornea was slightly hazy, but not markedly so; there was no definite staining. After 48 hours there was seen a fine keratitic haze which stained, and the lids were blistered. On the fifth day the cornea still stained and the iris pattern was not clear. On the ninth day merthiolate with diffusing factor was substituted for the saline washout. On the sixteenth day there was " very slight blepharitis and a little watery secretion; the cornea was less

opaque, with fine peripheral vascularisation." Treatment was then stopped.

The left eye showed intense blistering of the upper lid, and the cornea was hazier than that of the right eye. After 48 hours the blistering was still marked in the upper lid. Staining was present over a good deal of the superficial area. After 72 hours there was contraction of the third lid and formation of adhesions; the cornea was slightly hazy. On the fifth day the third lid was becoming fibrotic and blistering was still apparent; the cornea was densely hazy and the iris pattern could just be seen in places. Treatment was changed to merthiolate with diffusing factor and cod liver oil. On the twelfth day the redness of the lids was much reduced; there was some mucopurulent discharge. On the sixteenth day the cornea was densely hazy, having an appearance similar to that of the right eye of rabbit No. 11. The tissues were weakened and bulged, and there was a " sago " effect over the whole upper section.

Rabbit No. 14 followed much the same course as that noted in rabbit No. 13. The cornea of the right eye began to clear on the twelfth day, and there was also less discharge and less scarring. The left eye showed definite corneal changes, very slight blepharitis and much mucoid discharge. On the sixteenth day both eyes showed characteristic corneal scarring. The animal was destroyed and the eyes retained for sectioning.

The three white rabbits of this group were all irrigated with sodium bicarbonate 2 per cent. so as to form a background for the oils No. 1, 2 and 3.

Rabbit No. 15.—The right eye, at 96 hours, showed no indications of blepharitis or mucopurulent discharge, and the third lid was healthy and active. The cornea was definitely hazy. After eleven days the lids were healthy and the cornea very slightly hazy.

The left eye, at 96 hours, was closed; there was conjunctivitis, mucopurulent discharge, lid contractions and a fine generalised keratitis. On the twelfth day the cornea was hazy and there was fine marginal staining over a large area; upper lid contractions were forming.

Rabbit No. 16.—The right eye was one-quarter open after 72 hours; there was slight mucous discharge—no definite contraction of lids. There was a general corneal haze and fine staining was present in the central area in discrete, fine dots. After ten days there was very slight blepharitis and a faint corneal opacity; the conjunctiva was healthy.

The left eye was almost fully open after 72 hours and there was no lid contraction. There was localised staining of the cornea,

confined to the area of application of the mustard. On the tenth day a rather marked mucoid discharge was present; corneal haze was slight, but greater than in the right eye. Six fine white superficial dots could be seen.

Rabbit No. 17.—The right eye, after 72 hours, was one-third open; there was mucopurulent discharge and slight contraction of upper lid, with blistering of lower lid. The pupil was small. On the tenth day the eye was closed and there was a mucoid discharge. However, the cornea presented only an almost imperceptible haze.

The left eye exhibited rather greater mucoid discharge than the right eye, with a slight degree of lid contraction. The cornea was hazy and there was a moderate staining area. After ten days only a slight mucoid discharge was present, and there was an extremely fine keratitic haze on the cornea.

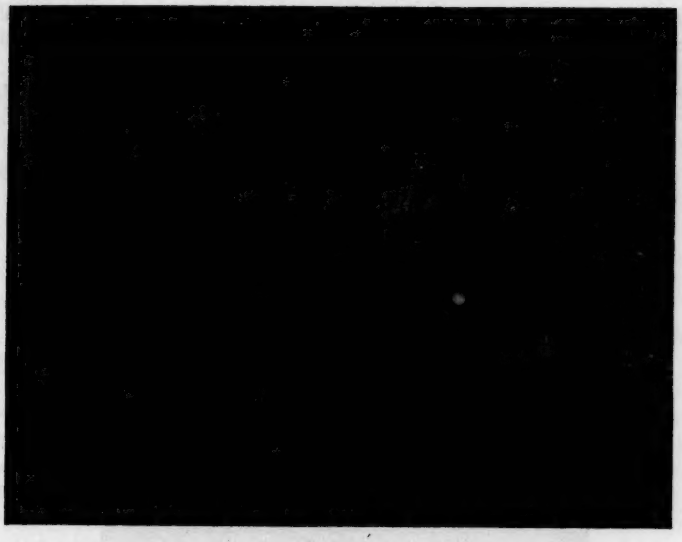
Rabbit No. 18 was the control rabbit (referred to on page 71) which was employed to examine the chemical interaction between liquid mustard and the tissues of the eye.

The Ascorbic Acid Treatment Group

This group consisted of five rabbits of which four (one white and three brindle) received injections for six days of 500 mgms. of ascorbic acid, the first injection being given twenty minutes before the application of a drop of mustard. The fifth rabbit (brindle) acted as a control, having the same exposure and treatment but without receiving ascorbic acid injections. Five minutes after exposure to mustard the right eyes of all rabbits were irrigated with sodium bicarbonate 2 per cent., and cod liver oil drops were applied. Treatment was repeated twice daily. No external treatment was given to the left eyes.

The following description of progress presents a characteristic picture of the ascorbic acid group; therefore a detailed account of each rabbit is omitted.

Rabbit No. 19.—The right eye was half open after 20 hours. There was no discharge, only slight congestion of the conjunctiva and slight blistering of the lower lid. There was a staining area on the cornea between 9 and 11 o'clock, some oedema of the cornea with fine elevations over the centre; slight superficial keratitis around the original seat of injury. After 92 hours the eye was open; there was no blepharitis, and the lids and conjunctivae appeared perfectly normal. There was very fine staining about 2 o'clock—otherwise nothing to note. On the seventh day the eye appeared perfectly healthy and the lids were unaffected. When, on the eleventh day the eye was wide open and healthy, there was a very small vascular loop on the cornea near the point



RABBIT No. 19 (Ascorbic Acid Group).

Left eye photographed on the 9th day, having had no local treatment. The cornea is clear except for a very fine linear mark (*a*) just above the light reflex. There is no discharge, no lid contraction and no conjunctival changes.

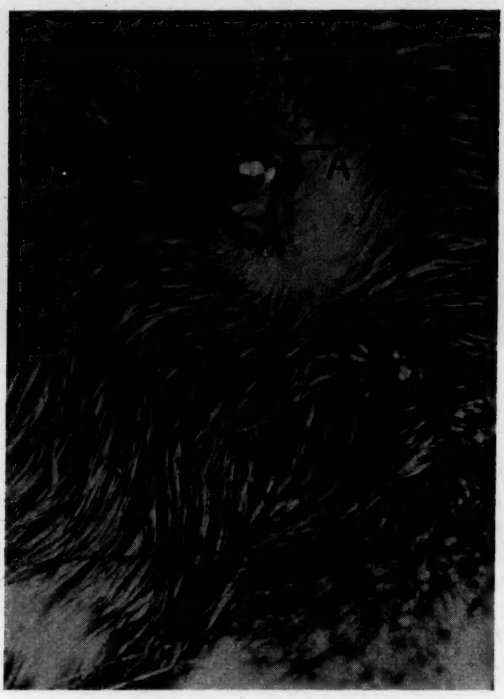
of application of the mustard. There was no inflammatory change and no appreciable corneal change. Treatment was stopped.

The left eye was one-quarter open after 20 hours, with very slight mucoid discharge. There was blistering in the upper and lower lids, and in the case of the upper lid it extended over most of the surface. There was a slight staining area about 11 o'clock, a small degree of superficial corneal oedema, and very mild keratitis. After 92 hours the eye was half open, with slight discharge and matting on inner surface of upper and lower lids—chiefly the upper lid; also, a very fine corneal haze. On the seventh day there was some contraction of the third lid, some scarring of upper and lower lids, slight conjunctivitis, and very faint corneal haze. On the eleventh day the eye was wide open; the lids were slightly red. There was no appreciable corneal haze.

With only small variations, such as the presence of pigment on the cornea of rabbit No. 20, the course of recovery of the other three rabbits receiving ascorbic acid and external treatment was identical, and characterised by mild reactions without secondary complications. The presence of pigment in the corneal wound had been noted in one or two other cases, and it was found that

this arose from the deposit of pigment from a very fine layer of this substance which traces the inner margin of the third lid of rabbits.

On the other hand, the control rabbit, No. 23, went through the three phases of severe contamination. Notes of the right eye



RABBIT No. 23 (Control rabbit of the Ascorbic Acid Group). Right eye photographed on the 6th day, having been treated with sodium bicarbonate and cod liver oil from the start. There is a large band of keratitis (*a*) extending from above downwards, with an upper projection of irregular shape occupying the centre of the cornea. There is some blepharitis in the lower lid.

on the eighth day described marked mucopurulent discharge, thickening of inner lid and dense corneal haze on the upper third. At the same time the left eye showed typical deep keratitis.

In the rabbits that received ascorbic acid there appeared little difference between the right eyes having irrigation and applications of cod liver oil twice daily, and the left eyes, which did not

receive local treatment. In one case, however, lavage and cod liver oil did appear to advance the rapidity of recovery.

The comparison between these four rabbits and the fifth of the group, was quite the most impressive feature of our study. Professor Sir A. Frederick Banting who visited the department, was particularly interested in the ascorbic acid group, and the apparently powerful influence of ascorbic acid on tissues subjected to the usually devastating action of mustard gas in drop form.

Histological Report

Taken from the left eye of rabbit No. 11 and the right eye of rabbit No. 12.

The effects are most marked in the epithelium and become less as we go deeper.

The epithelium.—In the early stages the cells undergo cloudy swelling with chromatolysis of their nuclei. The spaces between the cells become better marked. The more superficial cells are desquamated, leaving the basal layer standing for a time as a palisade of swollen, columnar cells with definite spaces between them. Finally, these also tend to be shed. Where healing has set in the epithelium grows over from the uninjured cells and covers the denuded area. This new epithelium forms a layer thinner than normal; the cells are all flattened, there being no columnar area.

Bowman's membrane is much less well defined in the rabbit than in the human and the changes are like those of the stroma.

The stroma.—The lamellae undergo cloudy swelling, so that in the affected area the cornea is much thicker than normal. The corneal corpuscles also undergo cloudy swelling with chromatolysis of their nuclei. Later the nuclei appear to fragment, appearing as small, dark, often rounded balls. Later still they appear to multiply so that the stroma becomes much more cellular than normal. Quite early there is a marked invasion of the affected area by eosinophile cells which can be seen leaving the engorged vessels at the limbus.

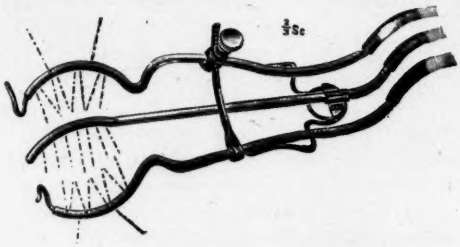
Descemet's membrane.—No definite change could be seen in Descemet's membrane, but in severe cases the endothelium became swollen and, in part, desquamated.

The anterior chamber.—In severe cases an albuminous exudate appeared in the anterior chamber, but in those cases in which the eye was not too badly damaged it disappeared later.

An Irrigating Speculum

The special irrigating speculum, made by Down Brothers, consists essentially of three arms. The upper and lower arms are designed to pass beneath upper and lower lids, much as does the

ordinary speculum but to a greater extent. The effect upon the lids is to render them about one-third open, so that the cornea is exposed and well clear of the lid margins, while the conjunctival folds and bulbar conjunctiva are not much in evidence. The idea behind this is to create a partial opening of the eye without undue pressure, and without locking off any areas which require to be subjected to the influence of lotions. This permits a retraction which, although uncomfortable without a local anaesthetic, can nevertheless be tolerated. When an anaesthetic is employed only a minimum quantity is required—for example, procaine 2 per cent. novocaine 2 to 4 per cent., cocaine 2 per cent. (2 drops). In view of the fact that during treatment the cornea is kept continually moist there is no contraindication to a minimal quantity of cocaine. The third arm of the speculum is curved to lie over the centre of the cornea. It cannot touch the corneal surface either during



insertion, or on spontaneous movement of the patient. It can be rotated away from the cornea during insertion, although this is not necessary.

All three arms are perforated at two angles by holes of graduated size, the small holes being nearest to the source of lotion, while those farthest away are larger, so that they can receive their share of fluid. The three arms are connected by fine rubber tubing to a combined metal pipe, which in turn, is attached by further tubing to a reservoir containing a litre or more of lotion. The same lotion may be used along all three arms of the speculum; or a stronger lotion such as, merthiolate 1:10,000 or biniodide of mercury 1:10,000 can be used along the arms which pass under the lids, while saline, glucose solution, or very finely divided vitamin charged oils, may be permitted to flow over the cornea through the third arm from a separate source. The corneal counter stream prevents the streams from under the lids from reaching the corneal surface, so that retained toxic products within the oedematous conjunctival folds pass harmlessly along the partially retracted lid margins. A specially designed trough, attached to the face, drains the solution away through rubber

tubing into a bowl. Thus the case can be left lying flat, and being irrigated continuously for many minutes. Practical trial at the Royal Air Force Hospital, Halton, has demonstrated that this procedure can be carried out successfully in cases of industrial chemical injury and of acute inflammation.

Conclusions

1. In a small percentage of animals there is some degree of natural resistance which definitely offers a barrier to the effects of liquid mustard.

2. With rare exceptions, so intense and rapid is the immediate reaction, that no local treatment can be hoped for that will prove helpful at this stage. The interaction of mustard and the secretions of the eye causes an alteration which leaves the mustard inactive as such after fifteen minutes. This alteration is probably an oxidation process which occurs after the initial reaction.

3. Irrigation with lotions that have a specific destructive effect upon the mustard is not recommended. Sodium bicarbonate 2 per cent. seems to be as helpful as any lotion, and there is reason to believe that the dehydrating effect of Bonnefon's solution may have merits. The use of atropine against the irritation of the iris leading to its contraction is clearly of importance.

4. Antiseptic washes, such as merthiolate 1:10,000 are clearly of value and would certainly be indicated if there was secondary infection.

5. Oil drops following irrigation appear to exert a favourable effect, and cod liver oil is probably best. There may be value in an oil with a high vitamin A content, but from this investigation we are unable to give any clear ruling on the respective merits of cod liver oil with added vitamin A and cod liver oil of B.P. standard.

6. There is reason to believe that the spread of corneal ulceration in the human eye could be arrested by the use of the specially designed irrigating speculum just described.

7. Saturation of the system with ascorbic acid, given intravenously to four rabbits, proved to have a remarkable effect in preventing the spread of keratitis and the progress of lid inflammation. Although only a few animals were treated in this way, the result in each case so outstrode all others, that it is safe to conclude that this method of treatment is well worthy of trial in any case of mustard contamination of the eye. The characteristic damage observed in the control rabbit of this group and the experience with the other eighteen rabbits of the series lends weight to this argument.

The result of this investigation, which had to be carried out

within a limited period, seems clearly to indicate that there are methods by which the effect of mustard contamination of the eye can be considerably mitigated. So far as we know, there has been no previous attempt to affect the course of mustard injury to the eye through the tissue barrier.

In the time at our disposal we were unable to investigate the period that could elapse between the injury and the administration of ascorbic acid. This, and the level of effective dosage must be subjects of further investigation. In the present investigation we used a very high dosage of ascorbic acid.

It is probable that there are substances other than ascorbic acid, cheaper and more readily available, that might exert a similar effect. This also calls for future study.

Since the completion of this work some further investigations have been undertaken with the object of discovering whether injections of ascorbic acid up to two hours after mustard injury and at the lower dosage level of 100 mg. is capable of controlling the corneal invasion. Examinations of animals thus exposed and treated proves that this is so.

At the same time some experiments were done in which sodium thiosulphate (10 per cent.)* in 500 mgm. doses intravenously was given. Examination of these cases indicates that this substance also, given in this fashion, possesses a definite value; but the results obtained from the ascorbic acid treatment are undoubtedly better. No other treatment in the form of lavage or oils was given in either of the latter series of cases.

Acknowledgment

We have to express our thanks to the Directors of Glaxo Laboratories Limited, who freely placed one of their research laboratories at the disposal of the Royal Air Force for this work.

We wish also to acknowledge the assistance given by Mr. R. M. Jenner, B.Sc., and Dr. J. Ungar in carrying out the experiments, by Mr. J. T. Marsh in taking the photographs of the external features and by Miss M. C. Lindsay in taking and collating an immense number of notes, and for her assistance in preparing this paper.

The histological examination and report was very kindly undertaken at the Royal Westminster Ophthalmic Hospital by Mr. Eugene Wolff, F.R.C.S.

* Sodium thiosulphate, $Na_2 S_2 O_3 5H_2 O$ is readily soluble in water. It should be stored in a closely stoppered bottle. A 10 per cent. solution can be used for injection, and it is sterilised by heat or filtration. Two grams daily and intravenously can be given with safety, and there are reports in the literature of much higher doses being given. Sodium thiosulphate can be obtained in solid form, or in ampoules for injection.

TABLE No. I—OBSERVATION GROUP.

RABBIT	Eye	Exposure to mustard	Lavage with Bleach Soln. 1·400	Lavage with Sd. Bic. Soln. 2%	Lavage with Saline 1·4%	Extracts from Clinical Notes.
		minutes				Cornea became hazy at second minute of lavage.
	R.	5	1×5 mins.	—	—	At 24 hours: corneal oedema and acute inflammation. At 72 hours: iris strongly contracted, cornea opaque. On 5th day: much muco-pus. On 7th day: eye completely glazed and blind.
1 White Female						Cornea very hazy with ground glass appearance after lavage.
	L.	15	1×5 mins.	—	—	At 24 hours: great conjunctival reaction, mucopurulent conjunctivitis, etc. At 72 hours: cornea intensely hazy. On 5th day: profuse discharge and lid haemorrhage. On 7th day: damage increased.
						No haze from lavage.
	R.	5	—	1×5 mins.	—	At 24 hours: eye slightly open, oedema of conjunctiva, cornea hazy, iris ill-defined. At 72 hours: mucopurulent discharge, cornea very hazy. On 5th day: cornea healthier and pupil normal. On 7th day: discharge moderate, fine keratitis.
2 Gray Male						No haze from lavage.
	L.	15	—	1×5 mins.	—	At 24 hours: much muco-pus, oedema + +. Cornea hazy and striated, iris clear. At 72 hours: thick pus discharge, diffuse keratitic change. On 5th day: membranous condition of lids, diffuse fine keratitis. On 7th day: cornea worse, iris pattern not visible.
						Cornea hazy with ground glass appearance after lavage.
	R.	5	1×5 mins.	—	—	At 24 hours: mucoid discharge, oedema of lids, conjunctiva gelatinous, cornea hazy. At 72 hours: oedema and corneal haze. On 5th day: discharge less, cornea hazy and staining. On 7th day: inflammatory process lessening.
3 Brindle Female						At 24 hours: eye entirely closed and very oedematous, covered with mucopurulent secretion, cornea hazy and abraded, staining over whole area; iris invisible.
	L.	Exposure without lavage	—	—	—	At 72 hours: more oedema and corneal haze than in right eye. On 5th day: discharge acute, deep uniform staining of cornea. On 7th day: no change.

TABLE No. I—OBSERVATION GROUP—*continued*.

RABBIT	Eye	Exposure to mustard	Lavage with Bleach Soln. 1·400	Lavage with Sd. Bic. Soln. 2%	Lavage with Saline 1·4%	Extracts from Clinical Notes.
4 Black Female	R.	Exposure without lavage	—	—	—	This case exhibited a strong natural resistance to mustard. The corneal damage was confined to the area of staining; there was no iris irritation. The chief feature was severe conjunctivitis. The eyes were clear by the 10th day. After clearing, the eyes were subjected to further experiment on the 12th day.
	L.					
4 (a)	R.	Exposure after application of oil	—	—	—	Second exposure 5 minutes after application of cod liver oil. At 24 hours: slight mucopurulent discharge, oedema of lids; cornea hazy. On 5th day: discharge ceased; lids dry and swollen. Fine keratitic changes. On 15th day: eye had cleared with cod liver oil treatment.
	L.		—	—	—	Second exposure 5 minutes after application of liquid paraffin. At 24 hours: oedema of lids greater than on right side. Cornea hazy. On 5th day: eye shut, slight discharge, blepharitis. Generalised corneal haze. On 7th day: c.l.o. substituted for liq. paraffin. On 15th day: keratitis and extensive scar tissue.
5 Gray Male	R.	*minutes* 5	—	—	1×5 mins.	At 24 hours: much oedema, thick pus. Almost impossible to see cornea. At 72 hours: oedema and conjunctivitis, haemorrhages. Difficult to see cornea. On 6th day: adhesions, membranous 3rd lid. Cornea staining. On 7th day: discharge. Scar tissue between 3rd and upper lids. Cornea very hazy.
	L.	Exposure without lavage	—	—	—	At 24 hours: slight mucopurulent discharge, not so great as on right side; cornea hazy in local area. At 72 hours: eye clearer, staining slight. On 6th day: discharge greater than on right side; 3rd lid membranous. On 7th day: adhesions; cornea less hazy than that of right eye

TABLE No. I—OBSERVATION GROUP—*continued.*

RABBIT	Eye	Exposure to mustard	Lavage with Bleach Soln. 1·400	Lavage with Sd. Bic. Soln. 2%	Lavage with Saline 1·4%	Extracts from Clinical Notes.
6 Brindle Male	R.	*minutes* 5	1×5 mins.	—	—	Typical corneal haze after lavage. At 24 hours: great oedema of conjunctiva. Extensive corneal staining. At 96 hours: lids matted, conjunctiva dull red. Cornea very hazy and staining. On 5th day: considerable infiltration of upper lid. Cornea difficult to examine. On 7th day: where seen, cornea hazy with pigment area.
	L.	Exposure without lavage	—	—	—	At 24 hours: oedema less than on right side. Cornea staining superficially and diffusely. At 96 hours: large membrane over whole of 3rd lid. Extremely red conjunctiva; moderate corneal haze and staining. On 5th day: discharge more marked than right side. Typical fine keratitis. On 7th day: no change.
7 Brindle Male	R.	*minutes* 5	—	1×5 mins.	—	At 24 hours: eye shut, mucopurulent discharge, oedema. Cornea slightly hazy over one fine area. At 96 hours: membranous 3rd lid, deep injection, typical keratitis. On 5th day: lids heavily injected. Corneal haze and staining. On 7th day: eye opening and cornea improving.
	L.	11	1×5 mins.	—	—	At 24 hours: eye shut, discharge more mucoid than on right side. Oedema more marked and cornea hazier than on right side; staining over half surface. At 96 hours: membrane on 3rd lid greater than right side. Cornea hazier than that of right eye. On 5th day: cornea staining over large area. On 7th day: no change.

TABLE No. I—OBSERVATION GROUP—*continued.*

RABBIT	Eye	Exposure to mustard	Lavage with Bleach Soln. 1·400	Lavage with Sd. Bic. Soln. 2%	Lavage with Saline 1·4%	Extracts from Clinical Notes.
8 Brindle Female	R.	*minutes* 5	—	1×5 mins.	—	At 24 hours: eye open, slight discharge. Cornea glazed, oedema. Corneal haze, characteristic staining. At 96 hours: marked conjunctival reddening. Mucopurulent discharge. Fine keratitis. On 5th day: moderate discharge. Cornea extremely hazy. On 7th day: no change.
	L.	Exposure without lavage	—	—	—	At 24 hours: discharge more than on right side. Oedema most extensive yet seen. Corneal area of staining not so large as in right eye. At 96 hours: marked discharge, marked keratitis; fine staining over most of cornea. On 5th day: lids completely matted; corneal change deeper than in right eye. On 7th day: cornea less hazy.
9 Brindle Male	R.	No exposure	1×5 mins.	—	—	As a control without mustard. After 5 minutes lavage with bleach solution the cornea showed the same ground glass effect as noted in other eyes irrigated with bleach. The epithelium appeared to become raised and slightly oedematous. The thickness of the cornea was unaffected. Eye was clear in 24 hours.
	L.	No exposure	—	1×5 mins.	—	After 5 minutes lavage with sodium bicarbonate solution the corneal pattern was not affected in any way.

TABLE No. II

TABLE No. 11

Rabbit	Eye	Exposure to M'tard	Sod. Bic. Soln. 2%	Bonnefon solution	Saline	B'nzoyl P'oxide (in oil)	No irrigation	Cod Liver Oil	Oil No. 1	Oil No. 2	Oil No. 3	Merthiolate 1:10,000 with diffusing ftr.	Condition at 24 hours	Conditon at 72 hours	Condition at 5 days	Condition at 10 days	No. of days treated
		mins.															
10 Black Male	R.	5	+	—	—	—	—	+	—	—	—	—	L/C ı□ D o C/K □ I o	L/C o D o C/K □ I o	L/C o D o C/K o I o		4
	L.	11	—	+	—	—	—	+	—	—	—	—	L/C + + D o C/K + I o	L/C + D + C/K + I o	L/C + D o C/K + I o	L/C + D o C/K o I o	14
11 Brindle Female	R.	5	—	—	+	—	—	+	—	—	—	+ 11th day on	L/C □ D + C/K + I o	L/C □ D + + C/K + + I o	L/C + D + C/K + + + I ?	L/C + + D + C/K + + I o	17
	L.	10	—	—	—	+	+	+ 7th day on	—	—	—	+ 7th day on	L/C + + D + C/K + I o	L/C + + D □ C/K + + I ?	L/C + + + D + C/K + + + I ?	L/C + + D + C/K + + I ?	17
12 Brindle Female	R	5	—	—	—	+	+	—	—	—	—	—	L/C + D □ C/K □ I o	Destroyed for microscopic examination. (No. 11 and 12)			2
	L.	10	—	—	+	—	—	+	—	—	—	—	L/C + + D + + C/K + + I o				2
13 Brindle Male	R.	30	—	—	+	—	—	+	—	—	—	+ 10th day on	L/C + D o C/K □ I o	L/C + D + C/K + + I o	L/C + D o C/K + + I +	L/C + D o C/K + I o	16
	L.	60	—	—	+	+	—	+ 6th day on	—	—	—	+ 6th day on	L/C + + + D + C/K + + I o	L/C + + + D + C/K + I o	L/C + + + D + C/K + + + I ?	L/C + D + C/K + + I o	16

Oil No. 1—liquid paraffin with added vitamin A 12,000 units and vitamin D 2,000 units per ml.

Oil No. 2—arachis oil.

Oil No. 3—cod liver oil with added vitamin A 12,000 units and vitamin D 2,000 units per ml.

L/C = lids and conjunctiva.
D = discharge.
C/K = corneal keratitis.
I = involvement of iris.

o = no involvement.
+ = slight involvement.
+ + = marked involvement.
+ + + = very serious involvement.
□ = less involvement than in opposite eye.

TREATMENT GROUP

TABLE No. II—*continued*

Rabbit	Eye	Exposure to M'tard	Sod. Bic. Soln. 2%	Bonnefon solution	Saline	B'nzoyl P'oxide (in oil)	No irrigation	Cod Liver Oil	Oil No. 1	Oil No. 2	Oil No. 3	Merthiolate 1:10.000 with diffusing ftr.	Condition at 24 hours	Condition at 72 hours	Condition at 5 days	Condition at 10 days	No. of days treated
		mins.															
14 Brindle Female	R.	30	—	—	+	+	—	+ 7th day on	—	—	—	—	L/C + + + D + C/K + + I ?	L/C + + D + C/K + I o	L/C + D + C/K + I o	L/C o D + C/K + I o	17
	L.	60	—	—	+	—	—	+	—	—	—	—	L/C + + D o C/K + + I o	L/C + + D + C/K + I o	L/C + D + C/K + I ?	L/C + D o C/K + I o	17
15 White Female	R.	6	+	—	—	—	—	—	+	—	—	—	L/C + D o C/K + I o	L/C o D o C/K + + I o	L/C + D + C/K + I o	L/C o D o C/K □ I o	12
	L.	15	+	—	—	—	—	—	+	—	—	—	L/C + + D + C/K □ I o	L/C + D + C/K + + I o	L/C + + D + + C/K + + + I o	L/C + D + C/K + + I o	12
16 White Male	R.	5	+	—	—	—	—	—	—	+	—	—	No clinical notes	L/C + D + C/K + I o	L/C + + D + + C/K + I o	L/C □ D o C/K □ I o	11
	L.	15	+	—	—	—	—	—	—	+	—	—	No clinical notes	L/C + D □ C/K □ I o	L/C □ D □ C/K □ I o	L/C + + D + + C/K + I o	11
17 White Female	R.	5	+	—	—	—	—	—	—	—	+	—	No clinical notes	L/C + D + + C/K □ I	L/C + + D + + C/K □ I	L/C + D + C/K + I	11
	L.	15	+	—	—	—	—	—	—	—	+	—	No clinical notes	L/C + + D □ C/K + I o	L/C + D + C/K + + I o	L/C □ D □ C/K □ I o	11

Oil No. 1—liquid paraffin with added vitamin A 12,000 units and vitamin D 2,000 units per ml.

Oil No. 2—arachis oil.

L/C = lids and conjunctiva.
D = discharge.
C/K = corneal keratitis.
I = involvement of iris.

o = no involvement.
+ = slight involvement.
+ + = marked involvement.
+ + + = very serious involvement.

TABLE No. III—ASCORBIC ACID GROUP

RABBIT	Eye	Exposure to Mustard.	Sod. Bic. Soln. 2% b.i.d.	Cod Liver Oil 8 drops b.i.d.	Intravenous Ascorbic Acid 500 mgms. u.i.d.	Condition at 24 hours	Condition at 96 hours	Condition at 7 days
		minutes				L/C □ D o C/K + I o	L/C o D o C/K □ I o	L/C o D o C/K o I o
19 White Male	R.	5	+	+	+			
	L.	Exposure without local treatment	—	—	+	L/C + D + C/K + I o	L/C + D + C/K + I o	L/C + D o C/K + I o
	R.	5	+	+	+	L/C + D + C/K + + I o	L/C + D + C/K + I o	L/C + D + C/K □ I o
20 Brindle Female	L.	Exposure without local treatment	—	—	+	L/C + D o C K □ I o	L/C o D o C/K + I o	L/C o D o C/K + I o
	R.	5	+	+	+	L/C + D + C/K + I o	L/C o D o C/K o I o	L/C o D o C/K o I o
21 Brindle Female	L.	Exposure without local treatment	—	—	+	L/C o D o C/K + I o	L/C o D o C/K o I o	L/C o D o C/K o I o
	R.	5	+	+	+	L/C □ D o C/K + I o	L/C □ D + C/K + I o	L/C + D + C/K + I o
22 Brindle Female	L.	Exposure without local treatment	—	—	+	L/C + D + C/K + I o	L/C + D + C/K + I o	L/C + D + C/K + I o
	R.	5	+	+	—	L/C + D + C/K + + I ?	L/C + D + C/K + + I o	L/C + + D + + C/K + + I ?
23 Brindle Female	L.	Exposure without local treatment	—	—	—	L/C + + D + C/K + + + I ?	L/C + + + D + + C/K + + + I ?	L/C + + D + + C/K + + + I ?

L/C = lids and conjunctiva
D = discharge
C/K = corneal keratitis
I = involvement of iris
o = no involvement
+ = slight involvement
+ + = marked involvement
+ + + = very serious involvement
□ = less involvement than in opposite eye

Oil No. 1—liquid paraffin with added vitamin A 12,000 units and vitamin D 2,000 units per ml.
Oil No. 2—arachis oil.
L/C = lids and conjunctiva.
D = discharge.
C/K = corneal keratitis.
I = involvement of iris.
o = no involvement.
+ = slight involvement.
+ + = marked involvement.
+ + + = very serious involvement.

ANNOTATION

The need for ophthalmic advice in Army Recruiting Centres

At the beginning of the 1914-18 war a distinguished surgeon on the Director General's staff advised that there was no need for ophthalmic surgeons in the medical service of the Army, all that was necessary in the case of ocular wounds was for the general surgeons to excise the eye. It was apparently a while before it was realized that some wounded eyes could be saved, that magnetic intra-ocular foreign bodies could be extracted, traumatic cataracts removed and sockets carefully repaired and rendered fit to receive a prosthesis.

Later in addition to the base hospitals where expert ophthalmic surgery was carried out, the establishment of ophthalmic centres attached to a casualty clearing station in each Army Corps did good work by attending to soldiers with ocular ailments such as corneal ulcers, abrasions, foreign bodies, iritis and lid disorders which required treatment for a short time before returning to the line.

Refractive errors were also dealt with in these centres where an optician attended with spectacle frames and glasses. The prompt correction of these errors was a factor in reducing some of the strain on men serving in the line. The need for the ophthalmic care of hundreds of gas injuries became evident later on. In the early days of chemical warfare 2,000 eye gas casualties arrived at one C.C.S, where there was no provision for ophthalmic treatment.

Although to-day the equipment for the ophthalmic service to the Army in the field is as admirable as it could be under the circumstances of war there have been deficiencies which may be termed prophylactic in character in the admission of men whose visual acuity is not only grossly below the approved standard but in whom one or both eyes have a serious organic disorder. These errors have occurred mainly among Supplementary Reservists Category C, a class of men holding as civilians specialist trade appointments in peace time, who were called up on general mobilization and within a week or two of the outbreak of war were sent to France to work in the docks at the base ports, on electrical installations along the lines of communications and as vehicle drivers. These men had been examined before the war on joining the Supplementary Reserve and before embarkation by "civil medical practitioners" employed by the Army. Among the first 300 returned from France as unfit for service in the Army the writer of this annotation saw cases exhibiting the following ocular disorders: aphakia with dense capsular remains and iris cyst, retinal detachment of long standing with multiple holes and old extensive choroido-retinitis, strabismus of over 70 degrees, high

myopia with myopic degeneration of the fundus, several cases of amblyopia ex anopsia; and from units in training locally cases of mixed and see-saw nystagmus, interstitial keratitis, large coloboma of the iris after abscision for a traumatic prolapse, bilateral choroido-retinitis juxta-papillaris with extensive visual field defect, advanced pigmentary degeneration of the retina and a number of gross refractive errors which reduced the visual acuity well below the lowest standard accepted for service in the Army.

It seems that much unnecessary expense in clothing, feeding, transporting and ultimately, after some weeks of hospitalization and medical boards, discharging such men from the Army could be avoided by setting up in England a regional or county appeal centre to which doubtful cases could be sent for examination by a medical board on which an ophthalmic surgeon of approved experience should serve. Such work could be done excellently by senior ophthalmic surgeons who have retired from hospital practice and have placed their services at the disposal of the Ministry of Health.

Many of the general physical defects among the sick returned from France such as arthritis, pes cavus, paralysis after anterior poliomyelitis, cardiac disorders and other obvious defects would have been evident on a half-minute inspection of the stripped candidate.

ABSTRACTS

MISCELLANEOUS

(1) **Weigl, R. (Lwow).—Rickettsia Rocha-Lima (Weigl) is not the cause of trachoma. (Rickettsia Rocha-Limae (Weigl) is nicht der Trachomerreger).** *Zentralb. f. Bakteriologie*, Vol. XCLIII, March, 1939.

(1) **Weigl** doubts the specificity of the Weil-Felix reaction in trachoma and rejects any relationship between trachoma and typhus.

The anal infection of lice by trachomatous material gave negative results, no Rickettsia Rocha-Lima being found.

He could detect no agglutinins against Rickettsia Rocha-Lima in the sera of trachomatous patients. Nor did he do so in cases which had a relatively high titre for OX19, OXK nor even for Rickettsia Prowaczeki.

This proves that Rickettsia Rocha-Lima is not only not identical with the causal agent of trachoma but has no relationship whatever to it.

The statement made by Cuénod and Nataf that Rickettsia Rocha-Lima is the same as the causative agent of trachoma is based on a mistake made during the experiments on lice.

A. F. MACCALLAN.

(2) **Saubermann, G. B. C. (Basle).—The influence of intensity of illumination on the size of the blind spot. (Ueber den Einfluss der Beleuchtungsintensität auf die Grössenmessung des blinden Flecks in normalen Auge).** *Ophthalmologica*, Vol. XCVII, p. 364, 1939.

(2) **Saubermann** shows in a study of 13 cases that the size of the blind spot varies with different intensities of illumination. In bright consulting rooms with strong daylight when the excitation of the entrance zone of the visual nerve is extinguished by contrast, the size of the blind spot is larger than with relatively weak artificial illumination with the eye fairly dark adapted whereby the contrast function is probably reduced.

ARNOLD SORSBY.

(3) **Adamantiadis, B. (Athens).—Corneal lesions in marble workers. (Keratopathie professionnelle des marbriers et des aiguiseurs).** *Ophthalmologica*, Vol. XCVII, p. 351, 1939.

(3) **Adamantiadis** draws attention to corneal lesions in marble workers (cutters and polishers). If no protective goggles are worn fine particles become deposited on the interpalpebral part of the cornea. Irregular astigmatism in the horizontal meridian of the cornea with diminution of vision results.

ARNOLD SORSBY.

BOOK NOTICES

A Manual of Diseases of the Eye. By CHARLES H. MAY and the late CLAUD WORTH. Extensively revised by MONTAGUE L. HINE, M.D.(Lond.), F.R.C.S.(Eng.), Surgeon to the Royal Westminster Ophthalmic Hospital and Ophthalmic Surgeon to Charing Cross Hospital. (8th Ed.). Pp. 536, 31 Coloured Plates, 371 Figures. Bailliére, Tindall & Cox. 1939. Price 16s.

The fact that this manual has reached its 8th edition is in itself a testimony of its popularity and usefulness to medical students and general practitioners to whom it is addressed. In this new edition some of the old subject matter has been deleted and 31 pages added to the text.

It has maintained its object in presenting the main principles of ophthalmic medicine and surgery and the practical application of these in a concise form. The common disorders of the eye are described at appropriate length and well illustrated in many instances by coloured plates. The rarer ocular disorders are described in a few lines.

The chapter on war injuries including the effects of poison gases on the eye is of contemporary interest.

To practitioners the chapter on therapeutic agents in ophthalmology will be especially helpful, and that devoted to the visual requirements of the public services will assist them in giving advice to prospective candidates.

The classification of developmental defects and degenerative conditions of the cornea, choroid, retina, optic nerve and lens has been carefully re-arranged. Cuénod and Nataf's work on the significance of Rickettsia bodies in the intestinal tract of laboratory fed lice, free from intestinal parasites, and their presence in trachoma is discussed. Also the recent treatment of this disorder by sulphanilamide is mentioned.

Some new conceptions about the pathogenesis of glaucoma, the surgical advances in the treatment of retinal detachment by diathermy and electrolysis, and the principles of corneal transplantation (keratoplasty) are described.

The chapter on tropical ophthalmology is interesting and useful, so are the comments about modern ideas concerning the action of atropine, miotics, allergic disorders and virus infections.

A few pages are devoted to the principles and practice of orthoptic training, these and the other sections dealing with the treatment of squint are well set out.

Six new coloured plates illustrating 17 ocular affections have been added to this edition. Some of the other illustrations are somewhat old. The background of figures 41 and 42 is mottled and these should be replaced in the next edition.

The printing and reproductions are admirable.

Surgery of the Eye. By MEYER WIENER, M D., Professor of Clinical Ophthalmology, Washington University School of Medicine, St. Louis, and BENNETT Y. ALVIS, M.D., Assistant Professor of Clinical Ophthalmology, Washington University School of Medicine, St. Louis. Pp. 445, Illustrations, 396. London: W. B. Saunders & Co., Ltd. Price 37s. 6d.

The most admirable feature of this book is the excellence of its illustrations which the author and the medically qualified artist have been at considerable pains to produce in order to demonstrate the main steps of certain common ophthalmic operations. These pictures are consistently good throughout the work and except for a few minor errors such as the disproportion in the size of some instruments and inadequate pupil dilatation particularly in some operations there are no faults and they show very lucidly stages in the operative technique, thus sparing the reader much tedious descriptive text matter.

The work is addressed to practising ophthalmologists and students and in the main the authors have adhered to their plan of describing

a single operative method which has stood the test of time and experience.

The book serves the purpose of an atlas of ophthalmic surgery. The printing, paper and production are excellent. Inevitably there are a few points which will not receive the approval of all ophthalmic surgeons.

The authors suggest that patients with conical cornea will tolerate cylinders as high as 30 dioptres or higher. There must be few who would endure a correction such as this. A good deal is written about resection of corneal scars but no comment is made on the degree of subsequent scarring and the visual results after such a procedure.

In cases of complicated cataract with a shallow anterior chamber the authors recommend cutting through the iris, capsule and lens in the section of the eye. Some surgeons would prefer to do a preliminary iridectomy first, to note the manner in which the eye responded and then, if satisfactory, to extract the opaque lens at a later date.

In the removal of intra-ocular foreign bodies the authors favour the posterior route, an incision being made with a Graefe knife through all the ocular tunics and into the vitreous. There is no description of the anterior route for extracting a magnetic foreign body, a procedure more generally approved of by many ophthalmic surgeons than the posterior route. Whilst it is true that in the case of relatively large irregular, ragged edged foreign bodies extraction by the anterior route may lead to damage to the lens and to iris entanglement and by the posterior route this may be avoided, the latter operation has generally more serious sequelae than the former.

In the surgical treatment of retinal detachment obsolete operations are described. Fig. 108 shows a large area of sclera treated by electro-coagulation in which the points of application are widely spaced. This is not in line with modern technique which aims at placing a few points of diathermy application close together around the margin of the retinal tear or tears. The recommendation of stenopaic glasses 24-48 hours after operation and that in 7 to 10 days the patient should "sit-up" would not be approved of by many surgeons interested in the fate of retinal detachment cases.

The authors advocate in cases of retinal detachment with a macular hole a circular barrage effected by trephining a series of scleral discs at this site and treating the choroid by chemical caustics. It is, in the reviewer's opinion, impossible to manoeuvre a trephine accurately at the macula unless part of the outer wall of the orbit has been removed.

In describing the operation for glaucoma iridectomy the authors do not emphasise the importance of making the incision 1 mm. behind the plane of the apparent corneo-scleral junction.

The frequent mention of vitreous loss in the intra-capsular cataract extraction is apt to give a false impression about the operation. The authors are not convinced of the advantages of a conjunctival flap in cataract surgery.

In describing perforating wounds the following statement is made "One should never temporise with a perforating wound of the sclera that involves severe injury to the ciliary region, even though light perception or vision is temporarily good at the time. Enucleation is positively indicated." Although the principle of regarding such wounds as potentially dangerous for some years is correct the reviewer feels that with early surgical attention, within two hours of the infliction of the wound, careful wound toilet and suturing of the sclera with a conjunctival flap covering the damaged area a number of eyes with useful vision may be saved. Such immediate operative treatment is worth a trial rather than sacrificing the eye at once. Excision may be undertaken in a few days if the inflammatory signs show no appearance of settling down.

The description of the technique of keratoplasty is inaccurate and Fig. 128 showing the method of corneal suturing designed by Tudor Thomas represents only a single cross stitch instead of the double one used by this operator. Attempts to fashion a shelf in the deeper layers of the recipient's cornea are now regarded as unnecessary.

Many surgeons would not agree to a crucial incision being made for removal of a chalazion. On page 318 the corners of such an incision are described as being "cut off with a small iris forceps."

In the treatment of epiphora in the new born the description of probing is incomplete in detail. The reviewer prefers to pass the probe through the upper canaliculus rather than the lower canaliculus advised by the authors. The risk of damage from splitting the lower canaliculus is not inconsiderable, whereas such an event matters little in the case of the upper canaliculus.

In the description of the advancement operation for the external rectus muscle the authors advise the excision of the stump before passing needles through the sclera. The tendon and muscle stump is valuable for the purpose of fixation with toothed forceps whilst the scleral sutures are being passed.

There are a few minor proof corrections which should be effected in the second edition, *e.g.*, page 317 gland of *Z*eiss, the final s should be deleted; meibomian gland requires a capital M; Fig. 372 substitute "internal" for "superior" rectus and in Fig. 294 the legend should read "levator palpebrae superioris" instead of "orbicularis."

The book will be a useful atlas and guide for the practising ophthalmic surgeon and students of ophthalmology.

NOTES

Oxford Ophthalmological Congress

AS already announced the Oxford Ophthalmological Congress will be held at Oxford from July 4–6, 1940. Prof. le Gros Clark will deliver the Doyne Memorial Lecture, and there will be a discussion on "Emergencies and complications of the operation for cataract."

* * * *

Dr. Jean Paul Marat

"IN a recent paper (*Hippocrate*, Vol. VII, p. 379, 1939) Dr. Henri Candiani protests against the unjust and cruel treatment which Marat has received. . . . . In 1776 he made an important contribution to ophthalmology in his 'Enquiry into a Singular Disease of the Eye,' in which, as Prof. Truc of Montpellier has shown, he gave a description of astigmatism which preceded the classical account of Thomas Young by more than twenty years. . . . . ." (From *Nature*, December 16, 1939).

Helmholtz (Physiological Optics) says "Young seems to have been the first to mention the asymmetry of the eye in different meridian planes."

* * * *

Pan-American Association of Ophthalmology

THIS Association was founded at the Congress of the American Academy of Ophthalmology and Oto-laryngology held at Chicago in October, 1939. The Association will hold its first Congress in October, 1940. Further information may be obtained from: Dr. M. E. Alvaro, Sao Paulo, Brazil, or Dr. Tomas R. Yanes, Habana, Cuba.

FUTURE ARRANGEMENTS

February 3, 1940.—North of England Ophthalmological Society, at Liverpool.

March 16, 1940.—North of England Ophthalmological Society, at Sheffield.

May 4, 1940.—North of England Ophthalmological Society, at Newcastle-on-Tyne.

July 4-6, 1940.—Ophthalmological Congress, at Oxford.